इंटरनेट मानक

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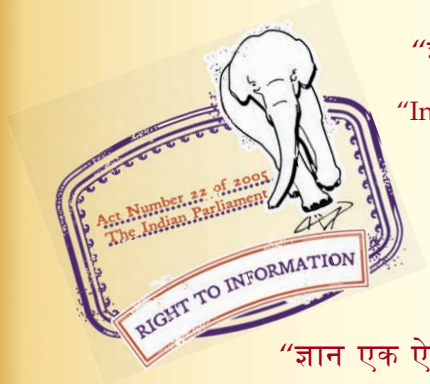
"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 15280 (2003): Quality Function Deployment [MSD 3: Statistical Methods for Quality and Reliability]



"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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भारतीय मानक

गुणता कार्य परिनियोजन

Indian Standard

QUALITY FUNCTION DEPLOYMENT

ICS 03.120.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

December 2003

Price Group 8

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Statistical Method for Quality and Reliability Sectional Committee had been approved by the Management and Systems Division Council.

In the last three decades, there have been several management tools developed to improve quality in the upstream stages, that is, starting from concept, design stage. Customers being the basic motivator for any organization to forge ahead in the current competitive environment, several approaches were developed to listen, understand and satisfy his requirements. Quality function deployment (QFD) is basically a mapping technique with the main aim of uniquely translating the customer's voice into the product design right from the concept stage and is carried through production and other subsequent stages. Implementing QFD is bound to provide a safe architecture for a purposeful design activity. Since QFD is a creative technique, it is very difficult to explain it with clear-cut borders. However, in spite of some minor divergences in practice and as based on several published books, articles and case examples, the central theme of the QFD subject is by now standardized. Some typical benefits of QFD implementation include:

a) Reduction of design time and cost,
b) Promotion of team work,
c) Minimization of engineering changes through out the life cycle of the product,
d) Improved customer satisfaction,
e) Systematically documented project history,
f) Warranty reduction,
g) Knowledge transfer in project, and
h) Incorporation of earlier engineering changes/minimization of the same.

This standard provides broad guidelines for implementing QFD in any organization. Essential conceptual explanations/elaboration of the basic terminology is also covered. An illustrative example relating to that of white board marker (WBM) is included at the end, conveying the conceptual mechanics involved. This standard can be used by any user for implementing QFD in relation to any product or service of concern.

Considerable help has been taken from Dr A. L. N. Murty and Dr T. V. Ranga Rao, from Indian Statistical Institute, Bangalore in formulation of this standard.

The composition of the Committee responsible for the formulation of this standard is given in Annex E.

Indian Standard

QUALITY FUNCTION DEPLOYMENT

1 SCOPE

1.1 This standard provides a typical methodology to apply quality function deployment (QFD) in any organization. The QFD aims at improving customer satisfaction by a systematic analysis of the customers' needs, competitive market pressures, identifying potential sales points and with an objective to build a better product or service.

1.2 Details of the various standard practices along with typical illustrations are given as broad guideline towards implementing QFD in practice.

2 REFERENCES

The following standards contain provisions, which through reference in this text constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
12801 : 1989	Pareto diagram and cause and effect diagram
14978 : 2003	New seven tools for quality management

3 TERMINOLOGY

For the purpose of this standard, the following definitions (*see also* **6** for typical illustrations) shall apply.

3.1 Quality Function Deployment (QFD) — QFD is a cross-functional planning tool and as well as a customer driven quality management system to create improved customer satisfaction. The basic idea of QFD is to inject/translate the voice of the customer throughout the marketing, R & D, engineering and manufacturing stages of product development. QFD employs a visual connective method that is easy to understand and convenient to deal in practice. The main focus of QFD is to identify the customer requirements and the related important design variables.

NOTES

1 Some published literature defines QFD as: A structured method in which customer requirements are translated into appropriate technical requirements for each stage of product development, planning and production.

2 It is desirable to introduce QFD in the early phases of design cycle and carried on throughout the product's active life cycle.

3 QFD is also applicable to the services and software sector.

4 Management commitment to improved customer satisfaction becomes more visible by systematic implementation of QFD.

3.2 Voice of the Customer — This term represents the totality of linguistically and/or quantitatively expressed customers' requirements/demands aided either by prior product usage experience/exposure or from an absolutely new futuristic perspective.

NOTES

1 Exploration of voice of the customer may start from an analysis of unfiltered information/expectations expressed in customers' own words.

2 Alternative terms for voice of the customer include raw data, source data, customer/user verbatim.

3 The output of the voice of the customer analysis is finally represented as customer demands (requirements) or inputs or WHAT's or objectives.

4 Some or as many as required customer requirements may have to be split into sub/sub-sub requirements called requirements at primary/secondary/tertiary levels (This may be done using Affinity diagram, Tree diagram/Cause and effect diagram or using suggestions of team members) (*see* **3.9, 3.10** and **3.11**).

5 Besides, other requirements (such as, that of regulatory agencies, internal customers, management) may also be incorporated in the WHAT's. However no priority ratings are assigned in QFD either for these WHAT's or the resultant HOW's. These additional requirements may be kept in mind while deciding on the ultimate priorities.

3.3 (Degree of) Importance Rating (IR) — Each of the customer inputs is rated on a 1 to 10 scale (1 for least important and 10 for most important) indicating the importance of the various inputs. IR represents either an individual preference rating by a single customer or a summary preference rating of the customers. IR is accomplished through various customer surveys obtained either directly or through mail or other means.

3.4 Sales Point Rating (SPR) — SPR is evaluated for each input by considering the potential business opportunities through scoring over competitors/ improvement in the particular input being considered.

The following scores are suggested :

a) No sales point (assigned a score of 1.0)

indicates very little additional business opportunity,

b) Moderate sales point (assigned a score of 1.25) indicates that either the business opportunity is modest or the IR is not very high or both, and

c) Strong sales point (assigned a score of 1.5) indicates a unique selling proposition to the company implying that the input is an important customer need and every competitor is doing badly about it.

3.5 Competitive Evaluation Rating (CER) and Rate of Improvement (RI) — CER is arrived at by rating each of the inputs on a 5 point scale and comparing the company's product against fixed number of competitors.

RI is determined through:

a) Selecting a target rating for each input by comparison with competitors rating or otherwise, and

b) Working out the RI as ratio of target rating and company's rating.

3.6 Final Importance Rating (FIR) — FIR is determined as the product of IR, SPR and RI. Some practitioners call FIR as absolute weight.

NOTES

1 The determination of FIR is confined normally only to the first phase.

2 Prioritization of FIRs results in identification of the most important input requirements by improving which, potential competitive business opportunities can be realized.

3.7 Four Phases of QFD — Typically a complete QFD system is composed of four consecutive phases which deploy the customer requirements throughout the implementation process. QFD is based on a successive translation of WHAT's (Objectives) into HOW's. Each phase's important outputs (that is HOW's — generated from the phase's inputs or WHAT's) become the inputs for the succeeding phase.

The typical terminology of the four phases is given in Table 1.

3.8 House of Quality (HOQ) — The principle tool for QFD is the house of quality depicted as a chart. The structure of an HOQ depends on the objective, phase and scope of the QFD project. Thus the planning activities in the four phases of QFD are summarized and presented using four houses of quality. In each HOQ, there are two sets of important ratings to be assigned. One is for the inputs (ROW WISE or for the WHAT's) of the phase and the other called technical rating/final technical rating is for the outputs (COLUMN WISE or for the HOW's).

3.9 Self-Interaction Matrix — This is represented in a triangular form with ${}_pC_2$ number of cells (p being the number of inputs or outputs as is the case), with each cell denoting the possible interrelationship or perceived correlation between each pair of inputs (outputs). The strength is expressed on a 5 point scale as for instance:

Strongly and positively correlated : ≅

Mildly and positively correlated : +

Table 1 Typical Terminology of Four Phases of QFD

(*Clause* 3.7)

Sl No.	Phase	Title	Title (WHAT's)	Outputs (HOW's)
(1)	(2)	(3)	(4)	(5)
i)	Phase I	Product planning	Customer requirements	Design requirements/technical measures/substitute/ counterpart quality characteristics/engineering parameters
ii)	Phase II	Parts deployment	Key design requirements	Part characteristics
iii)	Phase III	Process deployment	Key part characteristics	Process/production operations
iv)	Phase IV	Production deployment	Key process/production operations	Production/Quality control requirements and work instructions

NOTES

1 In any QFD project while phase I is essential, the rigour with which other phases are carried out depends on the complexity of the specific application.

2 The four phases are sometimes described in the literature as four houses of quality.

Uncorrelated : Blank/No symbol

Mildly and negatively correlated : –

Strongly and negatively correlated : *

3.10 Cross Correlation Matrix

This is represented in a rectangular $m \times n$ matrix form, where m is the number of inputs and n is the number of outputs. The mn cells of the matrix denote the possible relationships between the inputs and outputs. The relationship is usually expressed on a 4 point numeric scale as follows:

9 – Strongly correlated

3 – Moderately correlated

1 – Weakly correlated

Blank – No relationship

3.11 Targets or Goals

3.11.1 Targets are arrived at after

a) Prioritizing the inputs or the outputs as the case may be using importance ratings,

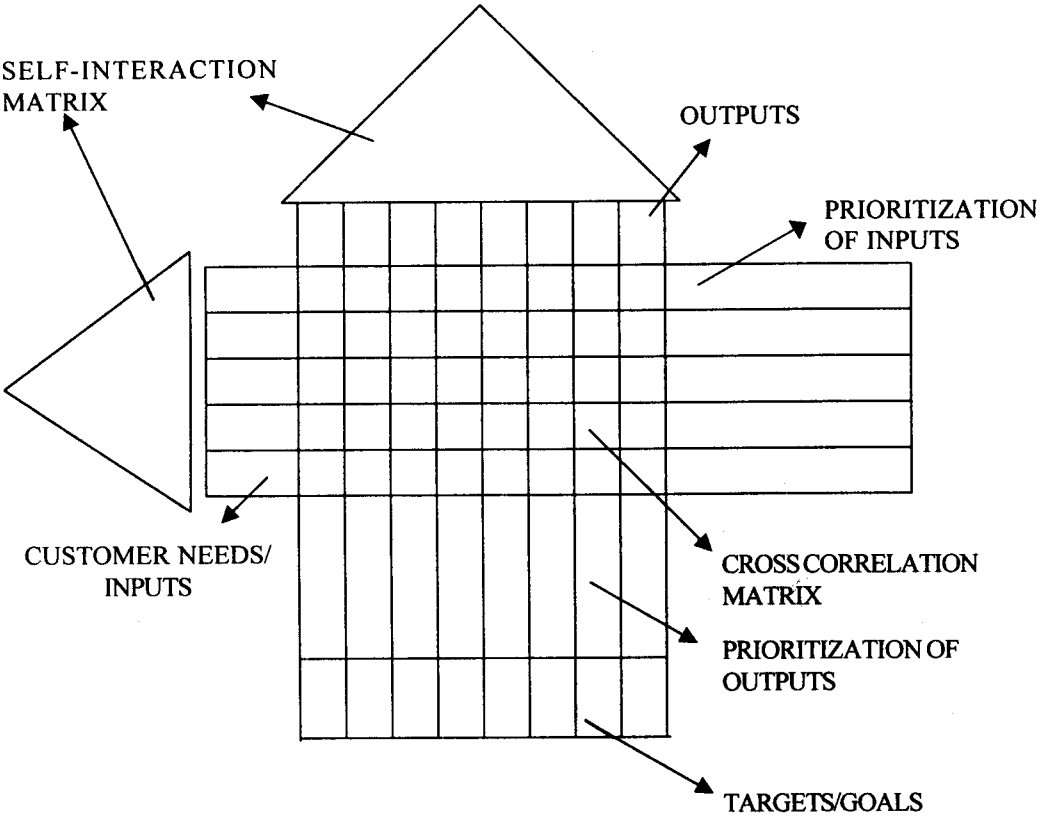
b) Considering the competitors' information wherever relevant and available, and

c) Brainstorming using company's judgement.

NOTE — Some times these are also referred to as quality plan targets.

3.12 The generic structure/schematic of HOQ is shown in Fig. 1 along with standard components.

3.13 Affinity Diagram (K J Diagram) — It is a powerful tool for organizing qualitative information into groups having similarity and employs mostly a creative rather than a logical process (*see* IS 14978). The affinity diagram gathers language or verbal data (ideas, opinions, issues, etc) and organizes it into



NOTE — *See* Annex A for a typical HOQ format. The format takes into account all the necessary information that is required to be gathered before proceeding to the next phase of HOQ.

FIG. 1 SCHEMATIC DIAGRAM OF HOQ

groupings based on the natural relationship among the items. This tool may be used in QFD to process the information related to WHAT's.

3.14 Tree Diagram (Systematic Diagram) — This is a useful tool representing information in a hierarchical structure (*see* IS 14978). This can be used in QFD for splitting inputs/outputs into primary, secondary and tertiary levels thus ensuring compilation of vital information at the minutest level.

3.15 Cause and Effect Diagram — This network diagram is a useful way of pictorially representing the anticipated relationship between several causes (including sub-cause and sub-sub-causes) and an effect. The causes are usually grouped under standard labels like man, machine, material and method. This is a useful tool for a systematic development of HOWs in every stage and also for developing mean's for achieving targets. For further details, *see also* IS 12801.

NOTES

1 All cause and effect diagrams can be re-written as tree diagrams.

2 This is a simple tool linking several causes (without interrelationship among them) with an effect.

4 SOME BASICS FOR SUCCESSFUL IMPLEMENTATION OF QFD

4.1 Selection of Projects

The following criteria broadly help in choosing a rewarding and appropriate QFD project:

a) Positioning a product of service closer to customer expectations,
b) Attaining market leadership through successful new/innovative product introduction,
c) Improving market share of existing products or services,
d) Providing a specific focus in particular cases like that of quality or reliability (including maintainability and availability) improvement, cost reduction,
e) Reduction of customer complaints, and
f) Improving the performance with respect to environmental parameters of the products or services.

4.2 Team Selection

4.2.1 Since QFD is a cross-functional approach, personnel from all the concerned departments must be involved in the project. The composition of the group can vary from phase to phase with, for example, in phase I it is advisable that personnel from marketing, R & D, QA/QC, production and process engineering, logistics, after sales service participate.

4.2.2 Similarly for other phases appropriate personnel may be included in the team depending upon the phase's objective.

4.3 Project Monitoring and Management Committee

Since the focus is on timely development so as to be ahead of the competitor it is better that the progress of the QFD projects is monitored by the top management against pre-planned and committed dates. Such management reviews also confirm to the team members that the top management is serious about the project. These reviews become more essential as the team composition changes at different phases of the project. As an alternative, all the new product developments can go through the QFD route by way of a management policy which ensures the integration of QFD into normal work pattern.

4.4 Feed Back Cycle

QFD is a part of continuous improvement cycle and, as such, at the end of the QFD project a review is required on whether the project is a success or otherwise. The missing links should be located and a second cycle of QFD is to be initiated for the product or service under consideration.

5 QFD PROCESS

QFD is executed through building of HOQs in all the four phases of deployment, that is, for translating customer requirements into the actual shop floor practices and work instructions, so that the customer is assured of obtaining the planned product/service quality. The steps involved are explained in **5.1** to **5.4** (*see also* **3.7**).

5.1 Phase I : Product Planning — Building HOQ, a Step by Step Approach

5.1.1 Building HOQ for Phase I broadly involves 12 steps. The schematic of HOQ for Phase I is given in Fig. 2. For typical format of HOQ refer to Annex A. The twelve steps are given below.

5.1.1.1 *Customer requirements (CRs)*

The first step of HOQ is to determine the customer requirements (INPUT's/WHAT's) for the products or services concerned. The primary requirements, which are the very basic customer demands, are normally expanded into secondary and tertiary requirements to obtain a more definitive list.

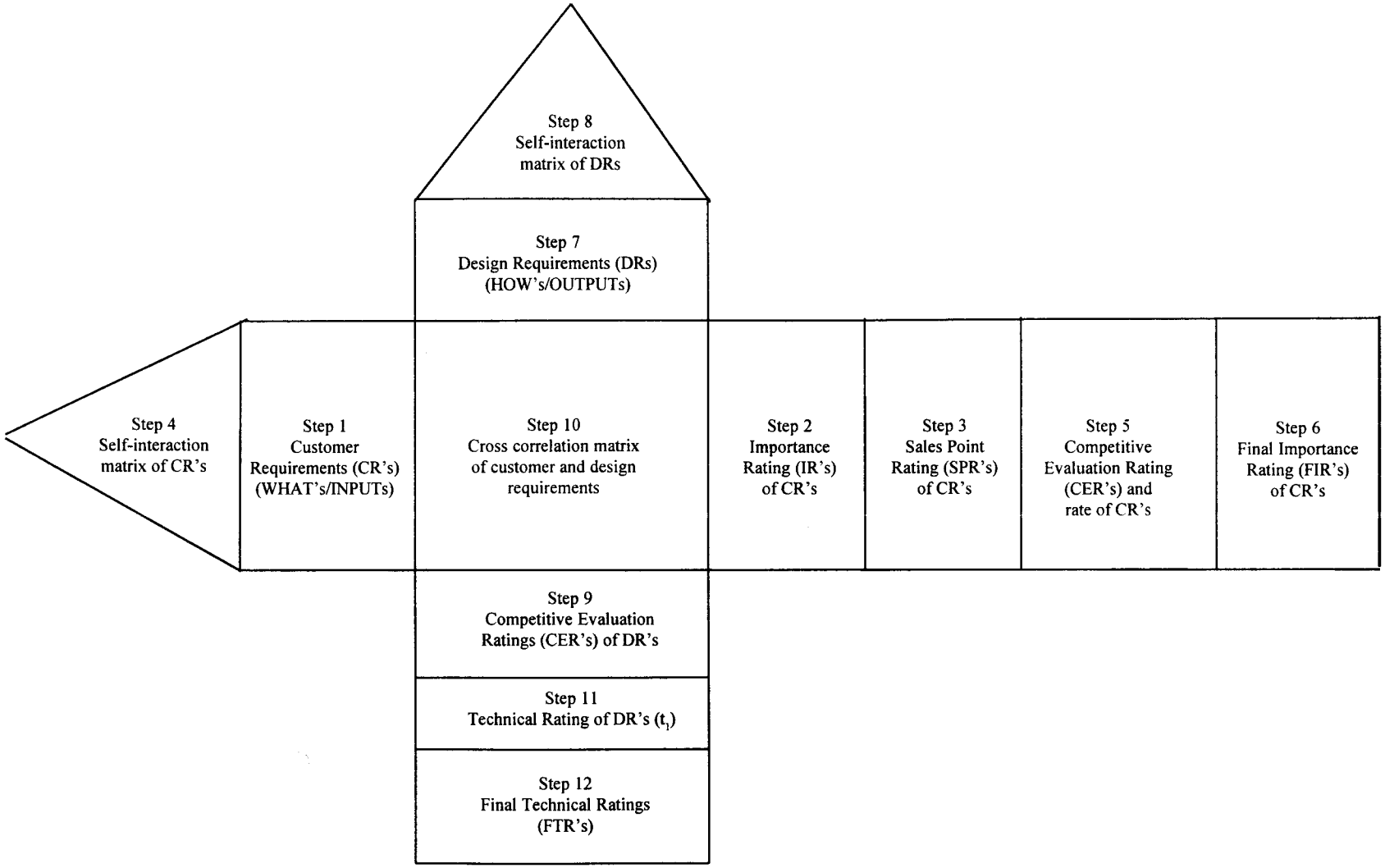


FIG. 2 HOUSE OF QUALITY — AN OUTLINE OF THE STEPS

Sources of obtaining this information typically include:

a) Market research,
b) Customer survey (mail/direct),
c) Warranty data and field return information,
d) Customer complaints/feed back,
e) Dealer inputs,
f) Sales department inputs,
g) Any other media information,
h) Safety and other regulatory requirements,
j) Phone,
k) In-depth personal interviews,
m) Value research,
n) Distribution inputs,
p) Trade shadows/trade magazines/customer reports, and
q) Sensitivity/conjoint analysis.

This step is the most critical and difficult step as it requires obtaining and expressing what the customer truly wants and not the thinking of company alone about the customer needs.

5.1.1.2 *Importance rating (IR)*

Customer needs are of different degrees of importance. IR represents the areas of great interest and high expectation expressed by the customer. It is a common practice for companies to prioritize the customer requirements so that company can attend to the most important needs without fail (*see also* **2.3**).

5.1.1.3 *Sales point rating (SPR)*

SPR helps in focussing on those specific customer requirements which offer potentially great business opportunities for the company to exploit (*see also* **3.4**).

5.1.1.4 *Self-interaction matrix of customer requirements*

The interrelationship or correlation among the customer requirements is represented in the form of a triangle. In this triangular diagram the strength of the relationship of every pair of customer requirements is represented in cells using a symbol (*see also* **3.8.4**). These interactions are to be taken into consideration while arriving at RI or computing FIR (*see also* **3.5** and **3.6**).

5.1.1.5 *Competitive evaluation rating (CER) and rate of improvement (RI)*

CER is determined after an extensive survey of customers (or their assigned agents) on relative superiority of the company's product *vis-a-vis* competitors in meeting customer requirements. CER is expected to bring out the current strengths and weaknesses of the company's products.

RI is then determined by establishing suitable targets for each of the customer requirements and in comparison with company's performance (*see also* **3.5**)

5.1.1.6 *Final importance rating (FIR)*

FIR is determined customer requirement wise as a product of IR, SPR and RI. The requirements with high FIRs indicate both importance and potential business to the company (*see also* **3.6**).

5.1.1.7 *Technical design requirements (DR's)*

DR's (HOW's) are identified by the concerned company's designers or development team or similar competent personnel with the sole purpose of translating all the customers requirements into company's designer language. It is better that the DR's are measurable, testable, controllable and evaluative of the whole product or service. Care should be taken to see that one or more DR's are identified for each of the customer requirements.

5.1.1.8 *Self-interaction matrix of DR's*

Similar to the **5.1.1.4**, the self-interaction matrix of DR's needs to be prepared to examine the interrelationship among DR's.

5.1.1.9 *Competitive evaluation rating (CER) of DR's*

Each of the DR's is to be comparatively rated on 5-point scale covering company's product and as well as competitors' identical or similar products. This rating has to be done by the company's designers or appropriate agencies. Representing the rating information through line graphs in both steps **5.1.1.5** and **5.1.1.9**, while may be treated as optional, however, adds to the elegance of the whole analysis. The CER of DR's brings out in a focussed manner the relative weaknesses, strengths and future goals of the company's products *vis-a-vis* competitors.

The RI is calculated as based on company's present performance with respect to the DR and in comparison with possibly the best competitor's evaluation.

5.1.1.10 *Cross-correlation matrix of customer and design requirements*

The cross-correlation matrix (CCM) is a systematic means of identifying the degree of relationship between each pair of customer requirement and DR. This identification is to be on a Blank - 1 - 3 - 9 scale done by the QFD team and is a vital step in the QFD process (*see also* **3.10**). If any specific row (customer

requirement) is totally blank, then it indicates that the particular CR is not likely to be addressed by the product design. As such, care should be taken to see that each row has one or more non-blank entries by selecting appropriate DR's.

5.1.1.11 *Technical rating (t_i) for DR's*

Let m and n be the number of customer requirements and DR's respectively, and

r_{ij} = strength of the relationship between the jth customer requirement and ith DR.

f_j = FIR of jth customer requirement, $j = 1, 2, \ldots\ldots, m$.

$$t_i = \sum_{j=1}^{m} f_j r_{ij}, \quad i = 1, 2, \ldots\ldots, n$$

5.1.1.12 *Final technical rating (FTR)*

FTR is obtained as a product of t_i with the corresponding RI's of DR's. Based on FTR values, prioritization of DR's has to be made particularly when 'n' is large (say more than 10). It is desirable that targets/ goals are fixed for each of the DR's at this phase, that is, before going to the next phase.

NOTES

1 While the above 12 steps constitute an integral and indispensable part of a complete QFD study, practitioners may choose to omit some of the steps in relation to the specific nature of the project being implemented. However, steps **5.1.1.1**, **5.1.1.2**, **5.1.1.7**, **5.1.1.8**, **5.1.1.10** and **5.1.1.11** are essential and core steps which cannot be eliminated even in a simple QFD project.

2 For the other phases of QFD project the relevant steps required for HOQ may be decided by the project team depending on the availability of essential data. However, the above short-listed six steps constitute the essential minimum required for HOQ at subsequent phases.

3 Some practitioners introduce design solutions in lieu of or as complementary to DR's in the Phase I. These are problem specific and convenience based approaches and may be adopted if found advantageous.

5.2 Phase II : Parts Deployment

In this phase, HOQ is used for deploying/translating key DR's (that is output of Phase I after appropriate prioritization of the DR's) into parts' characteristics. The QFD team should ensure that at last one or more sufficiently related part characteristics are suitably identified in order to satisfy the prioritized DR's or all the DR's if possible. This stage enables meeting the key DR's and ultimately ensuring maximum possible compliance with the customer requirements. The FTR's (of DR's) of the Phase I are used as the IR's for this phase.

5.3 Phase III : Process Deployment

In this phase, suitable process/production operations have to be identified using a HOQ for all the key part characteristics identified at the end of Phase II. This phase depicts the transition from development to execution of production phase. In this phase relevant processes manufacturing operations are identified so as to ultimately meet all the customers requirements.

5.4 Phase IV : Production Deployment

In this phase, production and quality control measures are identified so as to adequately meet all the key process requirements (as arrived at the end of Phase III) using HOQ. In addition, suitable auxiliaries, like procedures, work instructions are also developed as required. All the production personnel including operators shall be made aware of the various production control points/check points so that the importance of these controls in ultimately meeting all the customer requirements is understood and realized.

5.5 Typical Tools/Techniques Useful in QFD

A list of the tools/techniques generally that have been found useful in implementing QFD is given in Annex B.

6 TYPICAL ILLUSTRATION OF QFD

6.1 The QFD process is illustrated for a typical conference room item of white board marker (WBM). The WBMs are used for writing on white coloured laminated boards and the writing is easily erasable with a dry soft cloth or duster. WBMs are preferred to chalks (used for black boards) as they do not generate dust either in writing or in erasing. The four phases of QFD are illustrated for the WBM.

6.2 A detailed compilation of CR's and DR's and their related self-interaction matrices are given in Annex C. Since illustrating the full QFD with these lists is not convenient, only an abridged version of the same is provided in Annex D for illustrating the successive deployment in various phases.

6.3 For carrying out large scale applications of QFD, computer software is made use of in practice.

ANNEX A

(*Clause* 5.1.1)

FORMAT FOR HOUSE OF QUALITY (HOQ)

LISTING OF CUSTOMER REQUIREMENTS (INPUT's/WHAT's/DEMANDED QUALITY CHARACTERISTICS)

Customer Requirements				*Code No.*	*Importance Rating (IR)*	*Sales Point Rating (SPR)*	*Competitor Evaluation (CE)*					*Target*	*Rate of Improvement*	*Final Importance Rating (FIR)*
Primary Level	Secondary Level	Teritiary Level	1)				1	2	3	4	5			

NOTES

Scale for competitor evaluation: 1– Worst, 5 – Best

Evaluation of each of the customer requirements has to be plotted for both company's and competitors' product on 1 – 5 scale as a line chart using different symbols for each company.

Legend : □ – Our Company X – Company X △ – Company Y O – Company Z

1) Requirements may be split into higher level if necessary.

ANNEX B

(Clause 5.5)

TYPICAL TOOLS/TECHNIQUES USEFUL IN QFD

Sl No.	*Tool/Technique*	*Purpose/Objective*
i)	Pareto analysis	– To identify the vital few from trivial many – Useful in customer complaint analysis and in prioritizing the issues involved
ii)	Cause and effect diagram	– To systematically relate, link and present the causes of any problem/ phenomena with an effect – Not all problems can be effectively structured using this diagram. For causes which are interrelated, one can use relations diagram
iii)	Tree diagram/ systematic diagram	– A graphical tool to systematically relate means with single goal or objective – All cause and effect diagrams can be redrawn as tree diagrams
iv)	Affinity diagram	– To present the unfiltered verbal information of the customer into an organized and systematic network – Purpose is similar to that of C & E diagram, tree diagram and relations diagram but is drawn as based more on intuition than logic – Useful in more complex situations
v)	Matrix diagram	– Useful in assessing the relationship of several means with several goals/ objectives – Useful in forming cross relationship matrix of HOW's and WHAT's
vi)	Scatter diagram and regression analysis	– Scatter diagram is useful graphical tool in assessing the nature and strength of the relationship between a given pair of variables – Regression analysis is useful in modelling and determining the quantitative relationship between input and output variables or in assessing the self-interaction of several inputs or outputs
vii)	Failure mode effect and criticality analysis (FMECA)	– Is done usually as separately for design and process activities/stages – Useful in identifying modes and effects of any potential failure/defect – Risk priority number (RPN) is computed for each failure mode as based on the criticality of the failure, frequency of failure occurrence and degree with which the defect is detected at prior stages – Based on the RPN's a prioritization can be done for developing an action plan for the most important failure modes or those with high RPNs and also having very high severity ratings inspite of low overall RPN.
viii)	Fault tree analysis (FTA)	– Useful in the analysis of safety and environmental hazards – It traces the fault occurrence routes using a tree structure – All the failure routes are investigated for highlighting the most probable chain of occurrences leading to the fault
ix)	Process capability analysis	– It is done to determine the capability of a process to meet the specified customer/design requirements – Indices like Cp, Cpk are in vogue and an ideal value of above 1.33 or more indicate adequate compliance with the tolerances – It is assessed using situation specific methods such as histogram, control chart, normal probability plotting and analysis of variance (ANOVA)
x)	Control charts	– Useful in production deployment phase for controlling process and/or product characteristics – These charts and their interpretations are based on statistical theory
xi)	Design of experiments (DOE) and taguchi methods	– Provide a scientific method of conducting and analyzing experimental data to develop robust products and processes – This approach minimizes the cost of experimentation and also reduces the time for evolving robust products/processes – To understand the quantitative influence of different factors and their interactions over any response or output variable
xii)	Value engineering (VE)	– Primarily used to reduce the cost of a product as based on a pareto analysis of different cost components – It also used to identify and provide value enhancing features of any product/operations of a process – To provide value added product to the customer in relation to the price paid

ANNEX C

(Clause 6.2)

ILLUSTRATION OF CUSTOMER REQUIREMENTS (CR's) FOR DISPOSABLE WHITE BOARD MARKER (ERASABLE)

Primary	*Secondary*	*Tertiary*	*Code*
Cap fit	Opening/closing of cap	Smooth opening/closing	111
		Can hold the cap firmly	112
	Provision for holder for the cap while writing		12[1]
Pen grip	Holding properties	Convenient to hold	211
		Comfortable to hold for longer times	212
		Should not pain the fingers if held for long time	213
Physical appearance	Barrel labelling	Colour should be pleasant	311
		Instruction should be clear and visible	312
		Should contain all necessary dos and don'ts	213
		Instructions shouldn't fade during usage	314
	Barrel shape	Should be attractive	321
	Cap shape	Cap colour should be same as writing colour	331
		Cap appearance matching with the barrel	332
Writing Quality	Impression quality	Visible from distance	411
		Easy to erase	412
		No trace of ink after rubbing	413
		Letter thickness should be uniform	414
		Available in standard variety of colours	415
	Tip quality	Fits firmly into the barrel	421
		Should not cause smudging /overflow	422
		No deformation on use	423
		Does not dry up even after long use	424
	Application	Can be used on white board	431
		Can be used on paper	432
		Can be used on glass	433
		Can be used on polished wood	434
		Can be used on cloth	435
		Can be used on polyethylene	436
Cost	Price should be affordable/competitive		51[1]
Safety	Smell	Does not create a health hazard	611
Life	Last long	Should work for more time	711
		Should not break on fall	712

[1] Indicates no tertiary level requirement.

PART A : SELF-INTERACTION MATRIX OF CUSTOMER REQUIREMENTS — AN ILLUSTRATION FOR WHITE BOARD MARKER (ERASABLE)

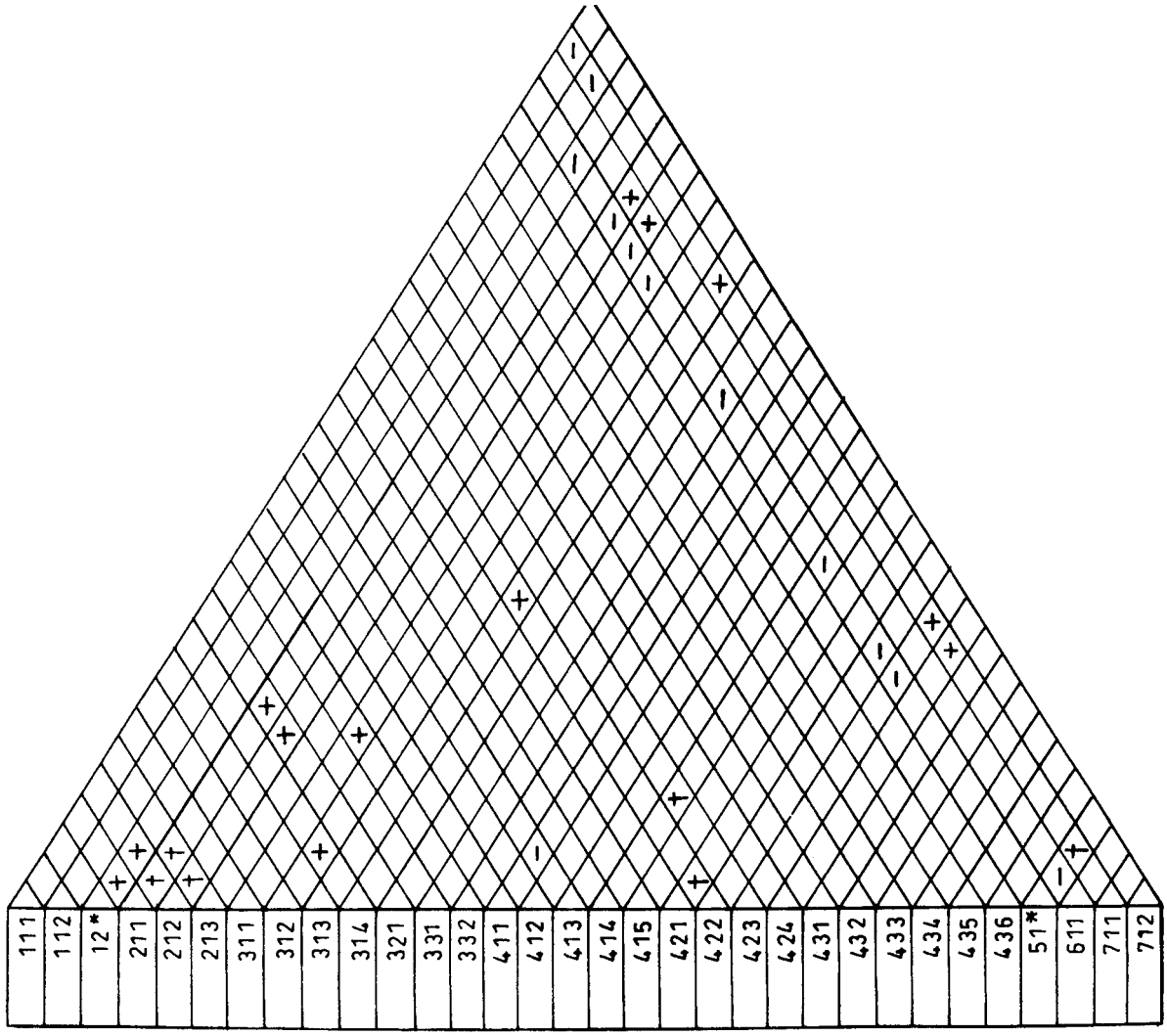


ILLUSTRATION OF DESIGN REQUIREMENTS (DRs) FOR WHITE BOARD MARKER (ERASABLE)

Primary	*Secondary*	*Code*
Aesthetics	Barrel label printing method	11
	Barrel label layout	12
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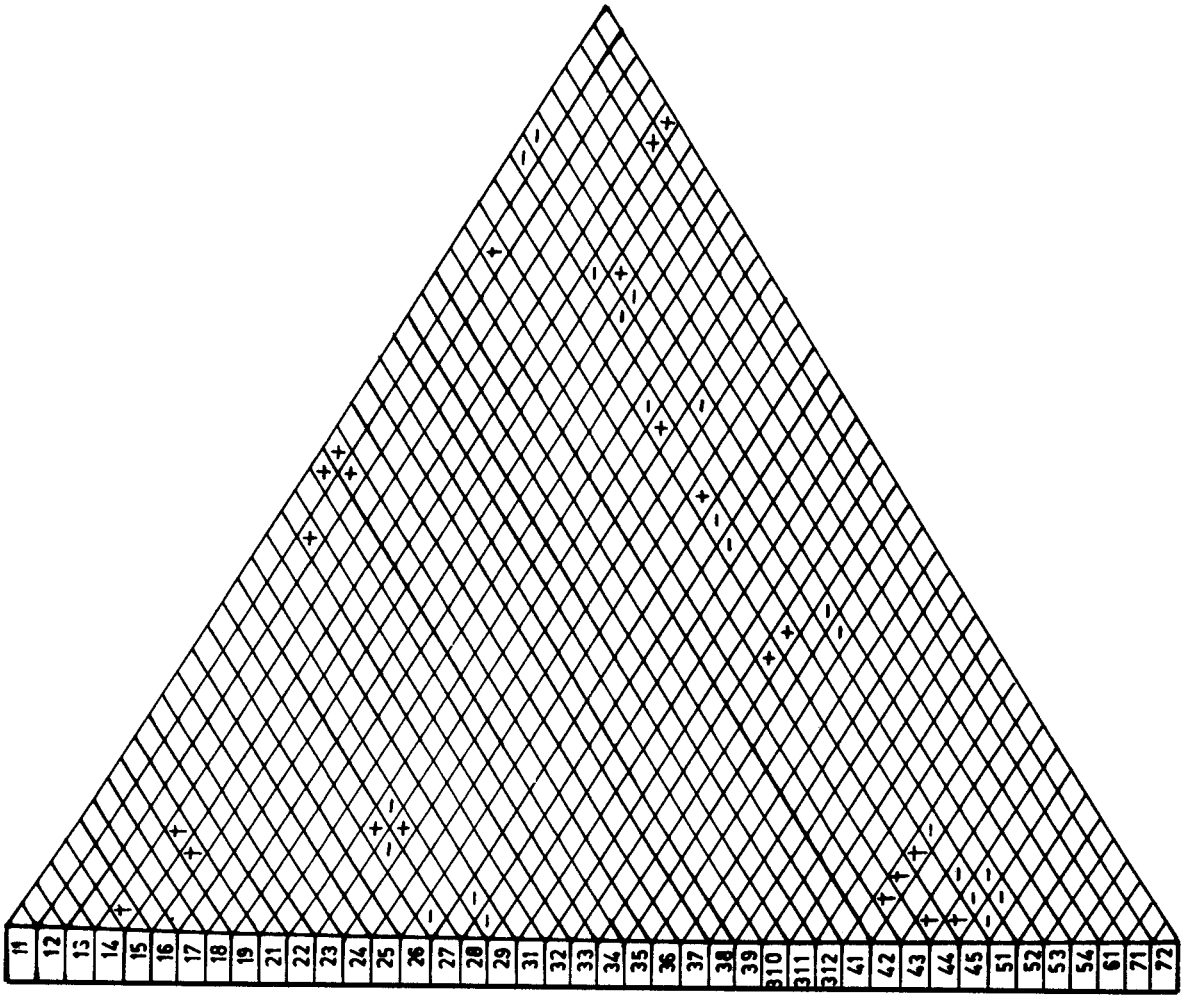
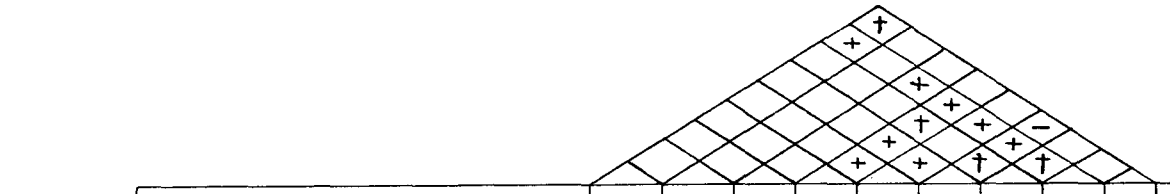
PART B : SELF-INTERACTION MATRIX OF DESIGN REQUIREMENTS — AN ILLUSTRATION FOR WHITE BOARD MARKER (ERASABLE)



ANNEX D

(*Clause* 6.2)

PHASE I : HOUSE OF QUALITY (PRODUCT PLANNING) — AN ILLUSTRATION FOR WHITE BOARD MARKER – ERASABLE (ABRIDGED VERSION)



Customer Requirements (CRs) / Design Requirements (DRs)	Cap design	Cap colour	Barrel design	Uniform flow of ink	Tip quality	Writing run length	Ink composition	Product cost	Clearance between cap and barrel	Importance rating (IR)	Sales point rating (SPR)	Competitor evaluation rating of CR's 1	2	3	4	5	Target for improvement	Rate of Improvement (RI)	Final Importance Rating (FIR)
Smooth opening and closing of Cap	3		1						9	6	1.00						5	1.25	7.50
Good impression Quality				3	9	9	9	9		10	1.50						5	1.00	15.00
Should have clear dos and don's			9			3		1		5	1.00						5	1.67	8.35
Affordable price	3		9			1	9	9		7	1.00						4	1.33	9.31
Should have long life			3		9	9	9	1		9	1.25						5	1.25	14.06
Good appearance	9	3	9					3		7	1.00						5	1.25	8.75
Safe to use			1	3			9	3	1	4	1.25						4	1.33	6.65
Competitor Evaluation of DRs (5 / 4 / 3 / 2 / 1)																			
Target DR	4	4	-5	5	5	5	4	3	3										
Rate of improvement (RI)	1.33	2.00	1.67	1.25	1.67	1.67	1.33	1.00	1.50										
Technical rating (TR)	129	26	294	65	261	296	405	288	74										
Final technical rating (FTR)	172	52	491	81	436	494	539	288	111										
Rank	6	9	3	8	4	2	1	5	7										

LEGEND : □ - Our company
× - Company X
Δ - Company Y
O - Company Z

† Strongly positively correlated
+ Moderately positively correlated
Blank No correlation
- moderately negatively correlated
* strongly negatively correlated

9 : Strongly correlated
3 : Moderately correlated
1 : Weakly correlated
Blank : No relationship

NOTES

1 Rate of improvement (RI) is worked out as for example smooth opening and closing of the Cap : Target for improvement/company's score = 5/4 = 1.25.

2 Final importance rating (FIR) for the same requirement = Importance rating × Sales point rating × Rate of improvement = 6 × 1 × 1.25 = 7.5.

3 Technical rating (t_i) for example for 'Cap design' = (3 × 7.50) + (3 × 9.31) + (9 × 8.75) = 129.

4 Final technical rating (FTR) = 129 × 1.33 = 172.

PHASE II : HOUSE OF QUALITY (PARTS DEPLOYMENT) — AN ILLUSTRATION FOR WHITE BOARD MARKER – ERASABLE, CONTINUED FROM PHASE I

Design requirements (DR's) \ *Part Characteristics*	Cap finish	Step dimension in the cap	Cap ID	Quantity of matching colourant	Print content	Labelling layout	Barrel dimensions	Ink dispenser type	Ink dispenser material	Tip profile	Tip material	Ink volume	Ink chemical composition	Ink drying rate	Homogeneity of ink mixture	Viscosity of ink mixture	Processing cost	Nipple OD	Nipple ID	Importance rating (IR) or FTR of Phase I
Cap design	3	9	9				3			1							3	3		172
Cap colour				9																52
Barrel design					9	9	9	3									9	9	3	491
Uniform flow of ink								3	3	3	9	1	3	3	9	9	3			81
Tip quality										9	9						1		3	436
Writing run length							9	9	9	3	3	9	9	9	9	9	1			494
Ink composition								3	3	1	3		9	9	9	9	1			540
Product cost	1			1	1	9	3	3	3	1	3	9	3	3	1	1	3			288
Clearance between cap and barrel		3	3														1	9		111
Technical rating (t_i)	804	1881	1881	756	4707	7011	10245	8646	7173	6649	8619	7119	10413	10413	10323	10323	7623	5934	2781	
Rank	18	16	17	19	14	11	5	6	9	12	7	10	1	2	3	4	8	13	15	

PHASE III A : HOUSE OF QUALITY (PROCESS DEPLOYMENT) — AN ILLUSTRATION FOR WHITE BOARD MARKER (ERASABLE) CONTINUED FROM PHASE II

Part Characteristics / *Process/Production operations*	*Design Process and Material Selection*							*Manufacturing Process*													
	Cap	Tip	Nipple	Barrel	Label	Ink	Ink dispenser	Weighing and charging	Mixing	Filling and weighing	Barrel extrusion	Top threading and deburring	Label printing	Dispenser inner core forming	Dispenser outer jacket wrapping and sealing	Tip forming	Nipple moulding and deburring	Cap moulding and deburring	Value engineering	Importance rating (IR) or TR, t_i of Phase II
Cap finish	3		1															9		804
Step dimension in the cap	9		3															9		1881
Cap ID	3		3															9		1881
Quantity of matching colourant	3																			756
Print content					9								9							4707
Labelling layout				3									3							7011
Barrel dimensions			3	9	3		9				9	1		1	3					10245
Ink dispenser type		3		3			9							9	3	3				8646
Ink dispenser material		3				3	9							3	3	3				7173
Tip profile	3	9	3				3									9	3	1		6649
Tip material		9				9	9							1	1	3				8619
Ink volume				9		3	9			9	3			3	3					7119
Ink chemical composition						9	3	9	9					9	3	1				10413
Ink drying rate						9		9	3											10413
Homogeneity of ink mixture		1				9		9	9					3	3	3				10323
Viscosity of ink mixture		3				9	3	9	9					3	3	3				10323
Processing cost	9	9	9	9	9	9	9	1	1	1	3	1	9	3	3	1	3	3	9	7623
Nipple OD	9		9	1							1						9	3		5934
Nipple ID		9	9	3							3	9				9	9			2781
Technical Rating (t_i)	169212	319797	209814	286131	141705	562302	526980	380871	318393	71694	150708	42897	132003	318078	224214	238158	121251	88414	68607	
Rank	11	4	10	7	13	1	2	3	5	17	12	19	14	6	9	8	15	16	18	

PHASE III B : DEPLOYMENT INTO DESIGN PROCESS (HOUSE OF QUALITY) — AN ILLUSTRATION FOR WHITE BOARD MARKER (ERASABLE) CONTINUED FROM PHASE III A BUT DONE BEFORE PHASE IV

Material Selection and Process Engineering / *Elements of Design Process*	Identification of critical dimensions/characteristics	Prescribing product/process acceptance criteria	Scrutiny of drawings	Scrutiny of design calculations/formulation	Prototype evaluation	Design/Process review (including activities like FMECA/FTA, etc)	Design/Process validation	Development of systems, procedures and work instructions	Training to augment skills	Corrective action	Quality cost evaluation	Importance rating (IR) or TR, t_i of Phase III A
Cap	9	9	3		3	1	3	3	1	3	3	169212
Tip	9	9	3	1	9	9	9	3	3	9	3	319797
Nipple	9	9	3		3	1	3	3	1	3	3	209814
Barrel	9	9	9	9	9	3	9	3	3	3	3	286131
Label		9	9		9	3	3	3	3	9	3	141705
Ink	9	9		9	9	3	9	3	3	9	3	562302
Ink dispenser	9	9	1	1	9	3	9	3	3	9	3	526980
Value engineering	1	3			3	9	9		3	3	3	68607
Technical rating (t_i)	18736731	20149290	6473973	8482674	17875134	8426016	17436546	6647823	6095592	16158348	6853644	
Rank	2	1	10	6	3	7	4	9	11	5	8	

NOTE — The deployment indicated here is of generic type and needs to be tailor made for specific part/material requirements.

PHASE IV : PRODUCTION DEPLOYMENT (HOUSE OF QUALITY) — AN ILLUSTRATION FOR WHITE BOARD MARKER (ERASABLE) CONTINUED FROM PHASE III A

Process/Production Operations \ *Production/Quality Control Requirements*	Deployment of systems, procedures and work instruction	Process capability evaluation	Development of process monitoring criteria and controls	Calibration of instruments and gauges	Development of QC/Inspection plan	Training to augment skills	Corrective action on process	Statistical process control (SPC) methods	Quality cost evaluation	Importance rating (IR)
Weighing and charging	3	9	9	9	9	9	3	3	1	380871
Mixing	3	9	9	1	3	1	3	3	3	318393
Filling and weighing	3	9	9	3	3	1	3	3	3	71694
Barrel extrusion	3	3	3		3	3	3	1	9	150708
Top threading and deburring	3	3	1		3		3	1	9	42897
Label printing	3		3		9	9	9	1	9	132008
Dispenser inner core forming	1		3		3	1	3	1	3	3180778
Dispenser outer jacket wrapping and sealing	1	3	3		9	1	3	1	9	224214
Tip forming	3	9	9	1	9	3	9	3	3	238158
Nipple moulding and deburring	1	3	9	1	3	1	3	1	1	121251
Cap moulding and deburring	1	3	9	1	3	1	3	1	1	88414
Technical rating (t_i)	4756129	10964496	13486935	4409137	12111519	6924508	8481009	4104913	8377903	
Rank	7	3	1	8	2	6	4	9	5	

NOTE — The deployment indicated here is of generic type and needs to be tailor made for specific processes that are actually being used.

ANNEX E

(Foreword)

COMMITTEE COMPOSITION

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